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On the $3d(^1D)$ and $3d(^1S)$ levels of singly ionized argon

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With 1 figure in the text

The spectrum of singly ionized argon has been investigated in the region 1900–13 000 Å and in the vacuum ultraviolet. The spectrum was excited by means of an electrodeless high-frequency discharge previously described [1]. The analysis of the wavelength material has resulted in the identification of about 120 new energy levels and has also led to a revision of earlier results.[1] The present paper deals with the $3d(^1D)$, $3d(^1S)$ and "$a\,^2P$" terms, an old problem which now appears to have come to a satisfactory solution.

Theoretically, the $3d(^1D)$ configuration gives rise to five terms, viz. $^2S, ^2P, ^2D, ^2F, ^2G$; the $3d(^1S)$ configuration consists of a ^2D term solely. The $3d(^1D)\,^2S, ^2P, ^2D$ terms were given by de Bruin [3]. Measurements in the extreme ultraviolet by Boyce [4] confirmed these levels except $^2P_{\frac{1}{2}}$, for which a new level indicated by two lines in the extreme ultraviolet was tentatively substituted. In de Bruin's list there is also a level assigned to $3d(^1D)\,^2F_{2\frac{1}{2}}$, which is not included in the AEL [2]. No $3d(^1D)\,^2F_{3\frac{1}{2}}, ^2G_{4\frac{1}{2}}, ^2G_{3\frac{1}{2}}$ levels have up to now been reported.

Two levels given by de Bruin [3], 186 728 and 186 750, have received different assignments by different authors [3, 4, 5], the $3d(^1S)\,^2D$ assignment suggested in the last reference being adopted in AEL.

Since all even ^2P terms in the actual region predicted by theory were occupied, it was not possible to find a configuration assignment for a term labeled "$a\,^2P$".

The $3d(^1D)\,^2S, ^2P, ^2D$ terms, including Boyce's $^2P_{\frac{1}{2}}$ level have all been confirmed in the present analysis by a large number of combinations in different spectral ranges with levels belonging to $4p, 5p(^3P), 4f(^3P)$ (doublets as well as quartets), $5p(^1D)$ and $4f(^1D)$, which are to a great extent newly found and identified. In fact, all the levels belonging to the configurations mentioned have now been found. Corresponding combinations have revealed $3d(^1D)\,^2F$ at about 9000 cm^{-1} below $3d(^1D)\,^2D$. In addition, there are two strong combinations with $4p(^1D)\,^2D$ in the infrared, viz. λ 10 111.595, $3d(^1D)\,^2F_{3\frac{1}{2}}$–$4p(^1D)\,^2D_{2\frac{1}{2}}$ and λ 9949.151, $3d(^1D)\,^2F_{2\frac{1}{2}}$–$4p(^1D)\,^2D_{1\frac{1}{2}}$. De Bruin's $3d(^1D)\,^2F_{2\frac{1}{2}}$ is not real.

The $3d(^1D)\,^2G$ term has also been found. A thorough investigation of the present wavelength material showed that the above-mentioned level, 186 750, depended on only one line, λ 6114, and 186 728 on two lines, λ 6172 and 6123, all very strong. These lines, however, could as well be identified as $3d(^1D)\,^2G_{4\frac{1}{2},\,3\frac{1}{2}}$–$4p$

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[1] For a complete list of references see AEL [2].

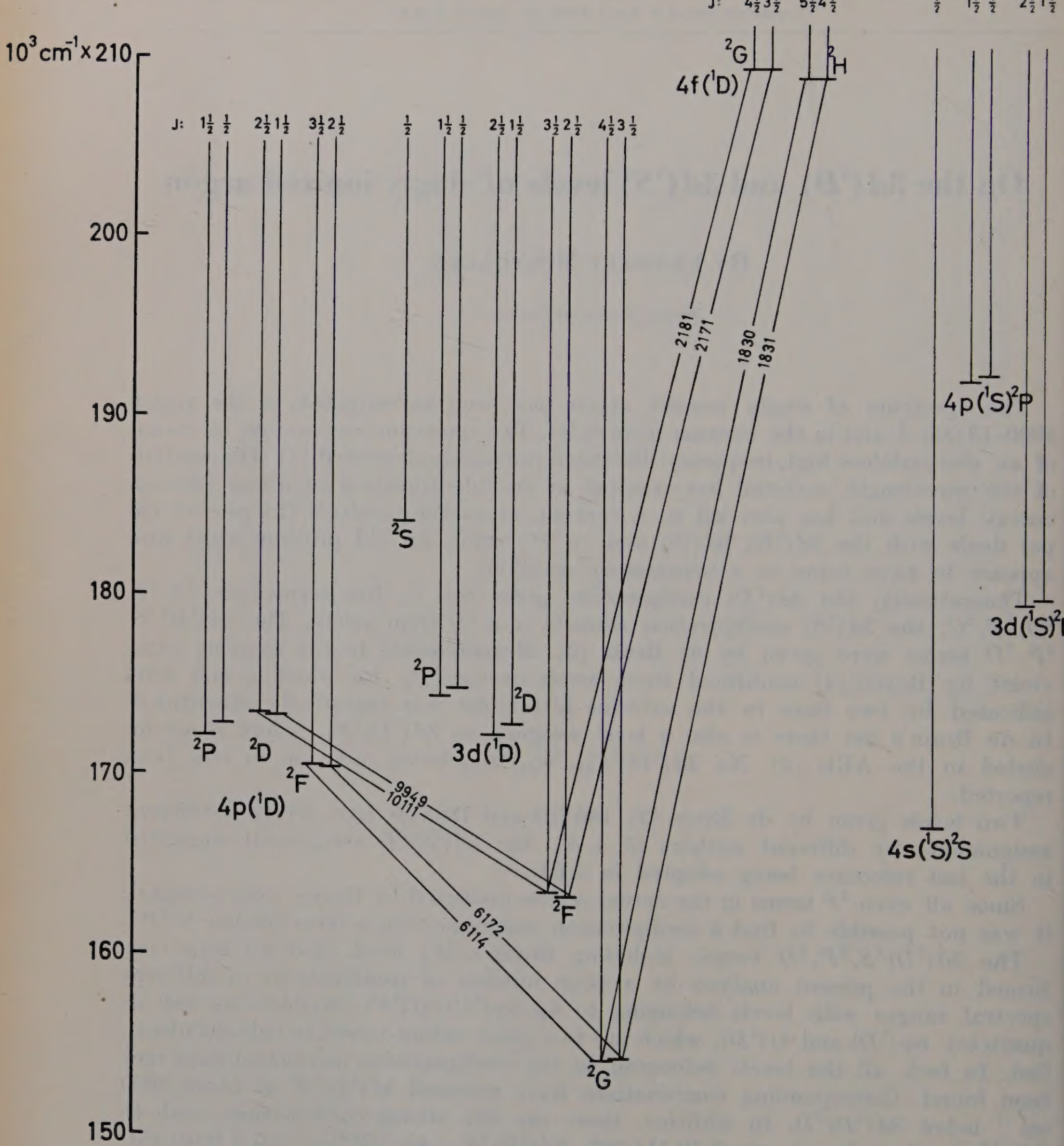

Fig. 1. Diagram of some argon II levels.

Table 1. $3d\,(^1D)$ and $3d\,(^1S)$ levels of Ar II.

$3d\,(^1D)\,^2S_{\frac{1}{2}}$	184 093.057	$3d\,(^1D)\,^2F_{3\frac{1}{2}}$	163 506.449
$^2P_{1\frac{1}{2}}$	174 409.831	$^2F_{2\frac{1}{2}}$	163 299.466
$^2P_{\frac{1}{2}}$	174 820.933	$^2G_{4\frac{1}{2}}$	154 181.426
$^2D_{2\frac{1}{2}}$	172 335.517	$^2G_{3\frac{1}{2}}$	154 203.970
$^2D_{1\frac{1}{2}}$	172 829.584	$3d\,(^1S)\,^2D_{2\frac{1}{2}}$	179 592.126
		$^2D_{1\frac{1}{2}}$	179 931.772

$(^1D)\,^2F_{3\frac{1}{2},\,2\frac{1}{2}}$, and this identification has now turned out to be the correct one, since two strong lines in the Schumann region, λ 1830.770 and λ 1831.526, have been found and identified as $3d\,(^1D)\,^2G_{4\frac{1}{2}}$–$4f\,(^1D)\,^2H_{5\frac{1}{2}}$ and $3d\,(^1D)\,^2G_{3\frac{1}{2}}$–$4f\,(^1D)\,^2H_{4\frac{1}{2}}$, respectively. There are also two weaker combinations with $4f\,(^1D)\,^2G$ in the same spectral region. The $3d\,(^1D)\,^2G$ term is about 9000 cm^{-1} deeper than the $3d\,(^1D)$ ^2F term, and its identification involves the rejection of the above-mentioned $3d\,(^1S)\,^2D$ levels, which are certainly not real.

The "$a\,^2P$" term gives a great number of combinations with $4p$, $5p\,(^3P)$, $4f\,(^3P)$ (doublets and quartets), $5p\,(^1D)$ and $4f\,(^1D)$ levels, which show that it is in fact a ^2D term which should be assigned $3d\,(^1S)$.

The actual level values are given in Table 1 with $3d\,(^3P)\,^4D_{3\frac{1}{2}}$ as a base, its term value, 132 327.281 cm^{-1}, being fixed in relation to the ground term by using Herzberg's [6] very accurate measurements in the vacuum ultraviolet.

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